Subatomic (Particle) Physics in Canada

- The Canadian particle physics community
- Our subatomic physics facilities
- Our particle physics program
- Connections with the international community

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Director, IPP
University of Toronto
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The Canadian Particle Physics Community

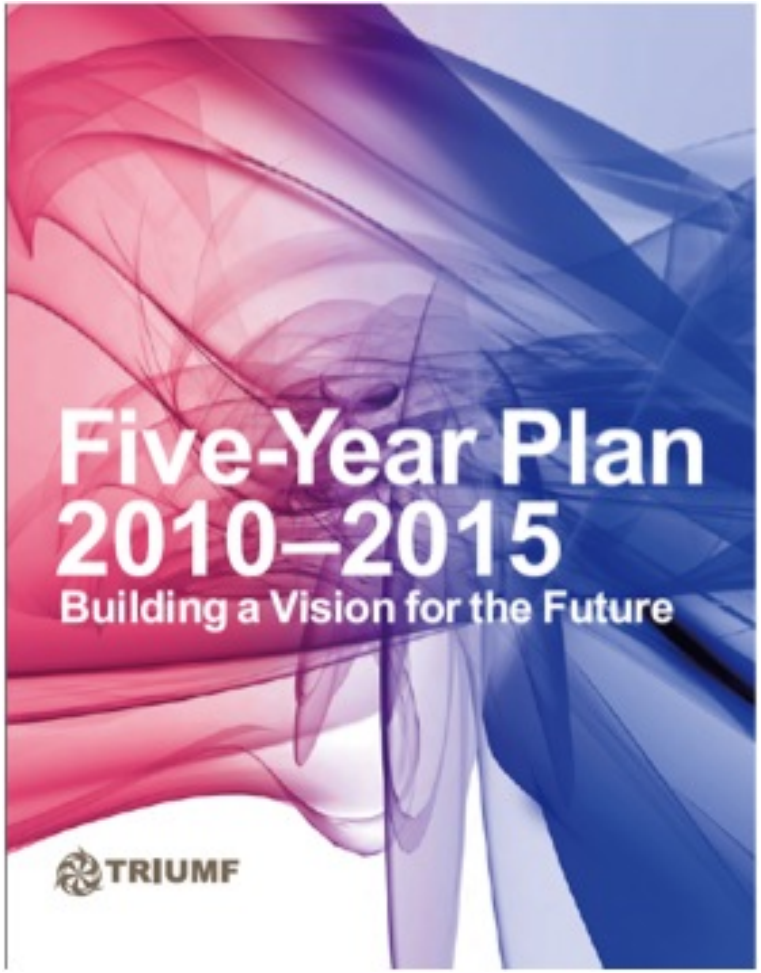
- 200 researchers from 25 Canadian institutions
- 15 institutional members of the IPP:

  Alberta, Carleton, Laurentian, McGill, Montreal, Perimeter, Queens, Regina, Simon Fraser, Toronto, TRIUMF, UBC, Victoria, Western, York

- Our community consists of
  - 125 experimentalists (ATLAS, T2K, SNOLAB, smaller experiments)
  - 75 theorists (phenomenology, string theory, formal theory)

TRIUMF

- National lab for subatomic physics
- Canada's steward for accelerator physics
- Operates world's largest cyclotron and suite of post-production radioactive beam accelerators
- Have a growing SRF group
  - Building a 1.3 GHz electron linac
  - First phase completed in 2013
  - Exploring ILC **and** CERN/SPL contributions
- Hosts Canada's LCG Tier1 centre
- Detector expertise (`BaBar`, `ATLAS`, `T2K`)



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SNOLAB

- Initial home of SNO experiment
- Cleanroom conditions, at -2000 m
- Expanded lab facilities over the last five years
  - 3-fold increase in volume
  - 4-fold increase in floor space
- Dark matter searches
  - DEAP/CLEAN dark matter search with Liquid Argon
  - PICASSO liquid droplet dark matter search
  - COUPP small scale bubble-chamber detector
  - SuperCDMS using solid state detectors
- Neutrino-less double beta decay searches
  - SNO+ with Nd-loaded liquid scintillator
  - EXO using gaseous Xenon
- Supernova searches
  - HALO using Lead and SNO neutral current detectors

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Defining the Canadian Particle Physics Program

- Build a community consensus around projects that:

  0. Have potential to answer crucial particle physics question(s);
  1. Involve a diverse group of Canadian particle physics researchers;
  2. Have financial support for development/construction/operation or exploitation of a 'full experiment' from Canadian funding agency, not just R&D money;
  3. Be a fully approved part of the experimental programme at the host lab or in the host country;
  4. Complement existing parts of the Canadian program. Our community is sufficiently small that we are better served by focused efforts on one experiment in each field/area/accelerator.

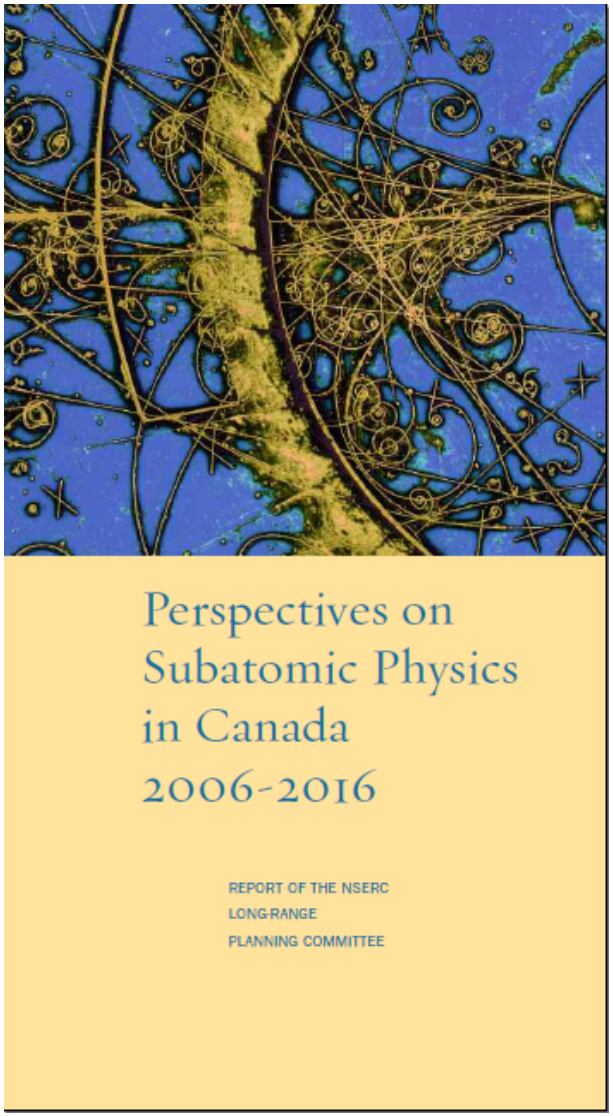
The Current Canadian Program

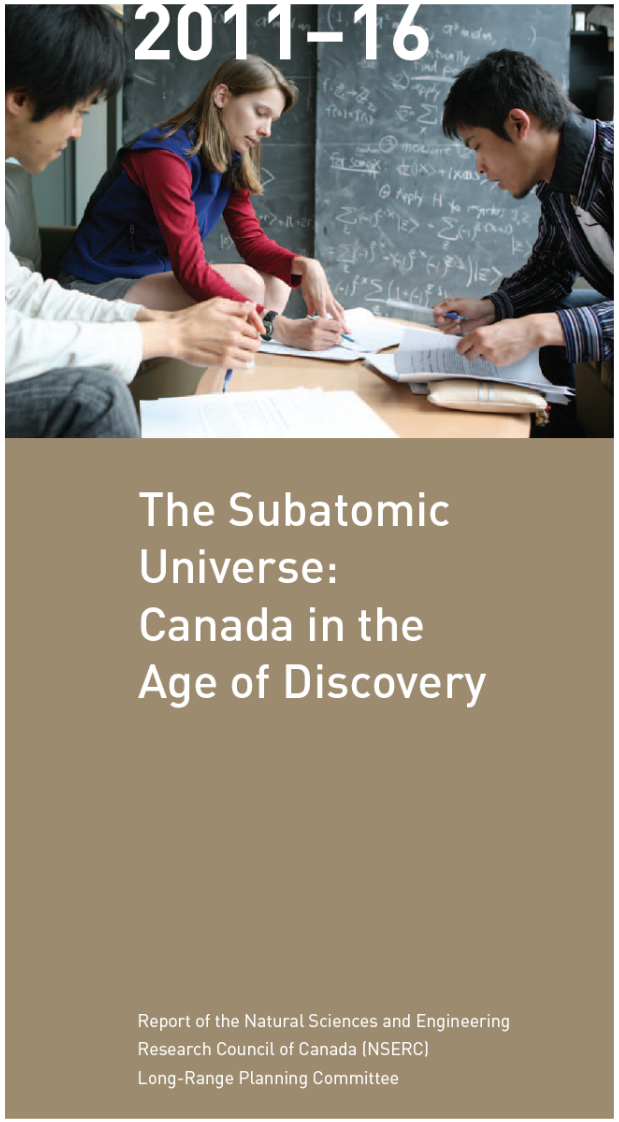
	Data-taking		Investigators
Experiment	Start	End	(FTE)
ATLAS	2009	2025+	43 (39)
BaBar	2000	2008	10 (4)
CDF	1992	2011	5 (1)
DEAP	2013	2017+	13 (8)
EXO-200	2011	2013?	6 (4)
$\pi \longrightarrow e$	2009	2012	4 (2)
PICASSO	2004	2014+	7 (4)
SNO+	2013	2017+	15 (9)
T2K	2009	2015+	19 (15)
VERITAS	2007	2015+	2 (2)

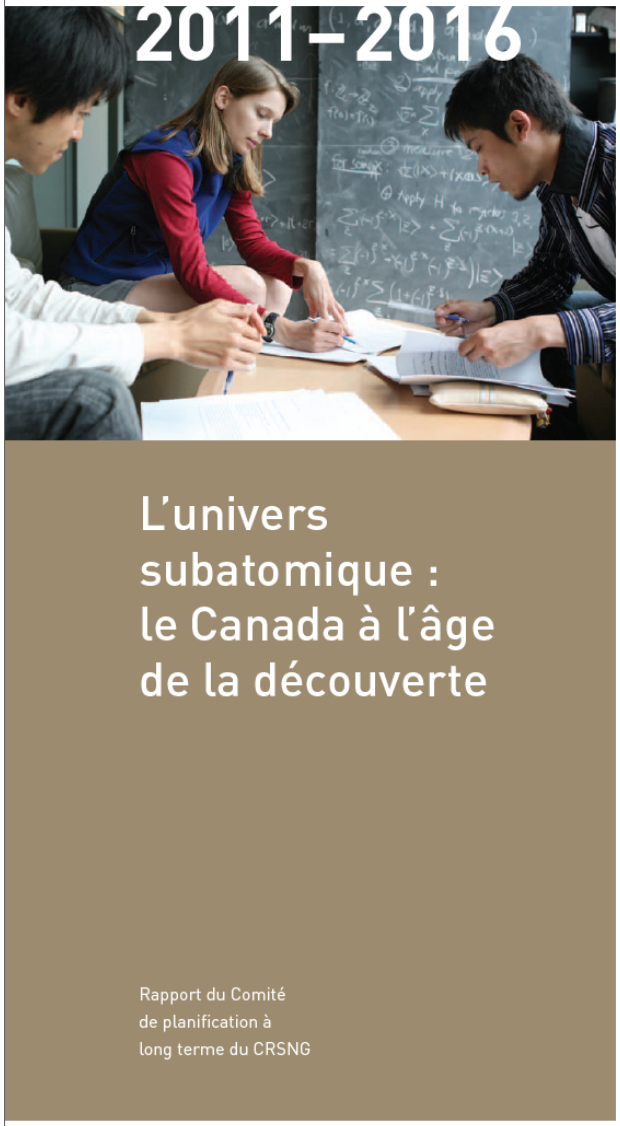
- Is this program serving the community?
  - Yes, $\approx$ 90 experimental FTEs (125 experimental faculty)
- We are in the final stages of transition from

SNO $\Rightarrow$ Picasso, SNO+, DEAP & ZEUS, CDF, BaBar $\Rightarrow$ ATLAS, T2K

Canadian Subatomic Physics Long Range Plans





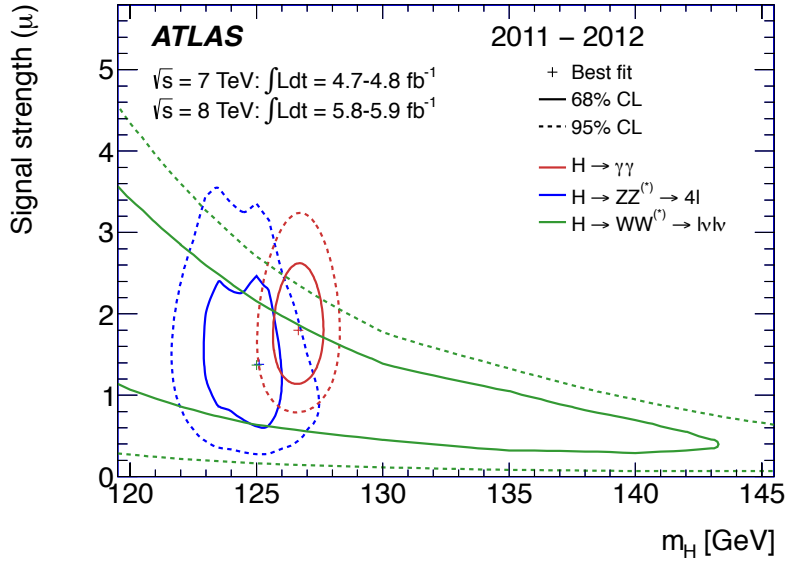


Overview of Particle Physics in Canada

- ATLAS: Explore the energy frontier at the LHC
  - Operations underway, fully engaged in physics, planning upgrades
  - 40 faculty and 100 postdocs/students maintaining detector and studying the data (25 PhD thesis completed)
- SNOLAB: Infrastructure complete
  - SNO+ and DEAP/CLEAN nearing completion
  - First measurements in the next few years
- T2K: θ_{13} measured, working on systematics
  - Canadian detector contributions working well after earthquake
  - Leading physics studies, low energy systematic checks at TRIUMF
- Future: Active in sLHC and ILC studies
  - TRIUMF developing SRF expertise (electron isotope facility)
  - Canadians prepared to contribute strongly to future HEP projects

ATLAS

- 5-7% of ATLAS collaboration
- Incredible start to data-taking
  - More than 20 fb^{-1} of data now
  - Higgs discovery is only first step
  - Canadians active in all areas
  - Tier1 centre(s) critical to re-processings
- ATLAS (and ATLAS-Canada) ready to exploit expanding datasets
- TRIUMF collaborating on sLHC injectors
- Canadians leading ATLAS upgrade R&D



- ATLAS-Canada continues to grow (1/2 of eHEP faculty hired in Canada since 2000)

Major commitment of 1/3 of the Canadian experimental community

T2K

- Canadians were the first foreign partners to sign original proposal
  - Off-axis beam concept invented in Canada
- Made major contributions to ND280
  - FGD, TPC now operational at J-PARC

November 2008

- OTR monitoring ν-beamline
- Canadians leading ND280 physics program
- A subset now members of SuperK improving far detector reconstruction
- Reducing systematics with cross-section measurements at TRIUMF

- T2K-Canada group:
  - 19 Faculty/scientists and 25 students/postdocs
- Canadian group as big as Japanese, US, UK and EU groups on T2K

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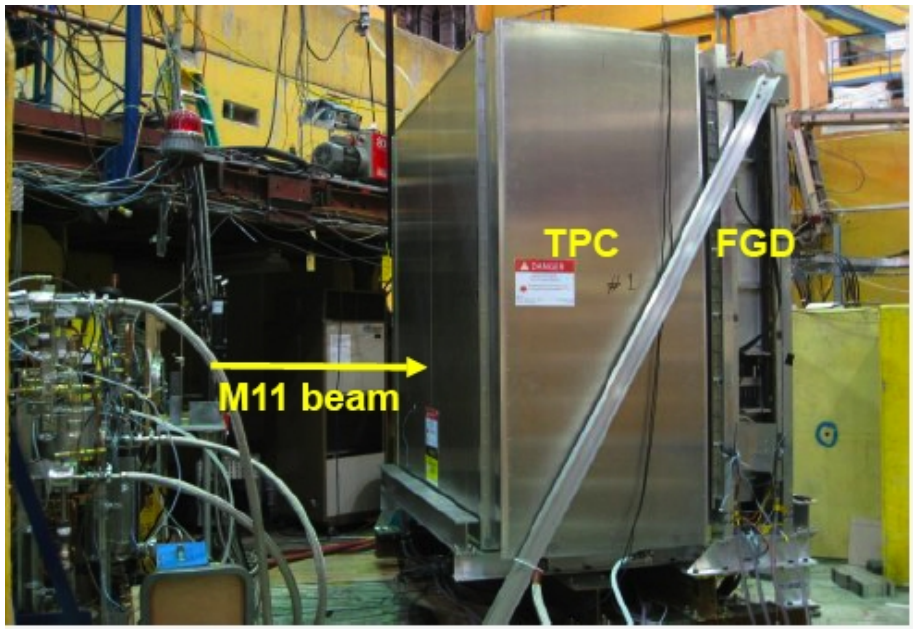

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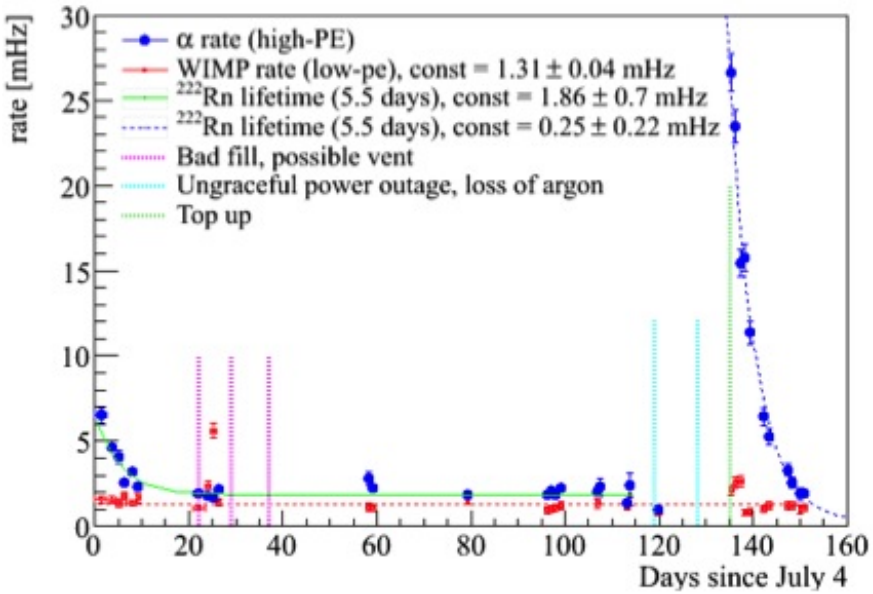
DEAP

- DEAP uses delayed signal in Liquid Argon to distinguish dark matter candidates from e/γ backgrounds
- 7 kg prototype is operating at SNOLAB
- $3 \cdot 10^{-8}$ photon rejection demonstrated (goal 10^{-9})
- Seeing radon on surface of acrylic vessel
- Now working to improve cleanliness of surfaces and purity of detector elements



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- Working closely with CLEAN, a US-led collaboration that will also use liquid Neon target
- Both should be taking data by 2014

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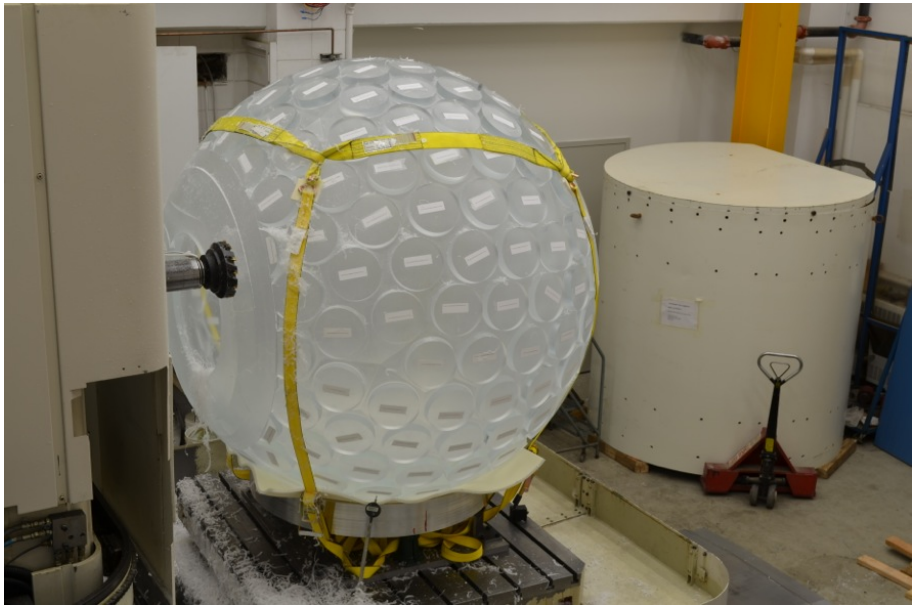

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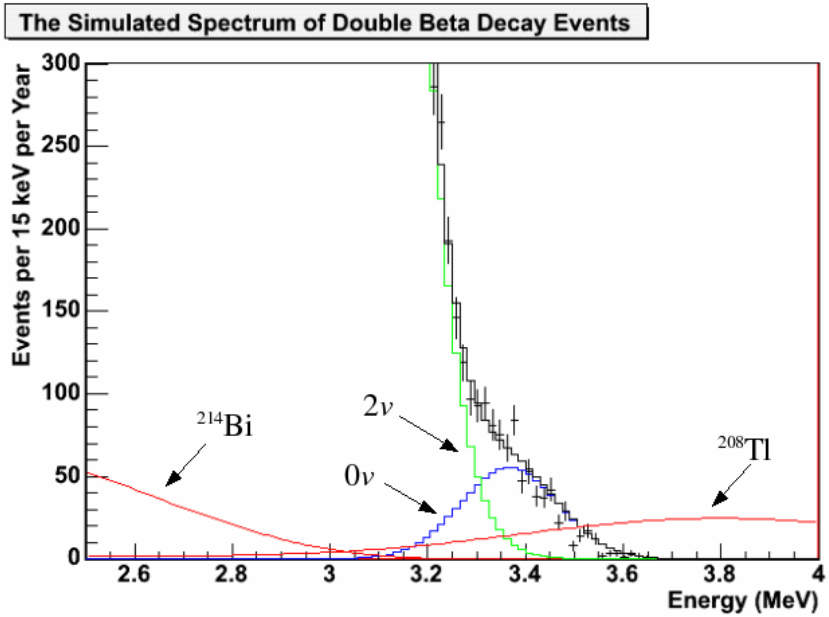
SNO+

- ^{150}Nd loaded liquid scintillator to search for neutrinoless double beta decay
- Significant engineering completed to *hold-down* buoyant acrylic vessel
- Have demonstrated transparency of 0.1% Nd suspension in scintillator
- Investigating isotope separation to increase active target mass without compromising transparency



- Signal from 2 years running (natural Nd)

- Construction well-underway. Expect first data-taking in 2014

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PICASSO

- Dark matter one of the compelling mysteries
- Search with super-heated droplet technology
- Low activity detector materials are key
- PICASSO steadily increasing mass
- 2.6 kg mass now in SNOLAB ladder labs
- New electronics exploits time-correlation significantly improving alpha/WIMP discrimination
- At the forefront establishing world's best spin-dependent limits

- Refreshing target modules as cleaner materials become available
- Cooperating with COUPP (Chicago/Fermilab) on next generation

The Future of the Canadian Programme

	Timeline		
Experiment	Start	End	Investigators
ATLAS	2009	2025++	40
T2K	2009	2015+	20
PICASSO/COUPP	2006	2013+	10
SNO+	2013	2015+	15
DEAP/CLEAN	2013	2015+	10
SuperB	2017 (?)	2025	10
Linear Collider,...	2020+	–	20-30+

- ATLAS is centre-piece of collider physics in Canada
- Converging on SNOLAB experimental programme
- Build future neutrino program on T2K contributions
- Possible involvement in SuperB
- Establish foundation for commitment to next collider

INSTITUTE OF PARTICLE PHYSICS

North American Cooperation in Particle Physics

- Important Canadian contributions to `BaBar` and `CDF`
- Natural geographic partners
- Began discussing North American cooperation on high energy physics at FALC meetings 3-4 years ago
- Have had a series meetings with Canadian proponents
  - Community: TRIUMF, SNOLAB, Perimeter, IPP
  - Agencies: NRC, NSERC, CFI, Industry ministry
- Suggested a list of possible topics of common interest:
  - SNOLAB/SUSEL experiments and R&D
  - Next generation long baseline neutrino experiments
  - Building a joint position on CERN relations
  - ILC development and SRF R&D
  - Facilitating movement of researchers among North American labs

Cooperation with Japan

- Natural trans-pacific ties between TRIUMF and Japanese labs
- Build on serendipitous cooperation with systematic contributions
  - T2K is a prime example of this
  - TRIUMF/RIKEN signed MOU
- Annual Canada/Japan (TRIUMF/KEK) symposia for the last 5 years
  - July 2009 at Canadian embassy
  - In conjunction with JPARC opening

Japan Particle Accelerator Science Symposium

Japan - Canada Collaboration and Internationalization in Particle Accelerator Science

July 7, 2009

Hosted by	**Embassy of Canada in Japan**
Co-hosted by	**National Laboratory for Particle and Nuclear Physics (TRIUMF)**
	Institute of Particle Physics (IPP)
In Cooperation with	**High Energy Accelerator Research Organization (KEK)**

CANADA 80 in Japan au Japon 1929 – 2009 カナダと日本

INSTITUTE OF PARTICLE PHYSICS

TRIUMF

Cooperation with CERN

- Canadians were 20% of the OPAL collaboration
- Among the first to commit to an LHC machine contribution (1995)
- Have a strong contingent on ATLAS
- Established Canadian participation in CERN summer student programme
- Canadian participants in CERN summer high school teacher program
- Contributions to LHC/ATLAS are highly visible in Canada
- Developing an industrial forum with potential to be CERN suppliers
  - Looking for projects that match our expertise in LHC upgrade path
- Some engagement at political level Associate Member discussions

Summary

- Canadian particle physicists have had a major impact on the physics of BaBar, CDF, SNO, ZEUS – our recently completed projects
- Starting to see the fruits of our investments in ATLAS, T2K and PICASSO
- A number of projects are on the horizon
  - Launch of the scientific program at SNOLAB:
    * DEAP/CLEAN and SNO+
  - Working to understand what's next on the Energy Frontier
- Significant community renewal going smoothly
  - Half of the particle physics faculty hired in the last ten years
- TRIUMF now formulating its next five year funding request
- Challenge: 30-40% increase in research activity while operating funding has remained **constant**